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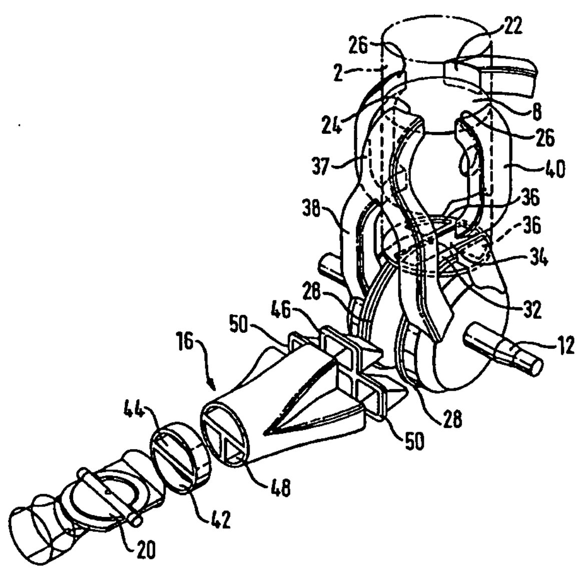
(54) Title: CRANKCASE SCAVENGED TWO-STROKE ENGINES

(57) Abstract



A crankcase scavenged two-stroke engine includes a piston (8) reciprocably mounted in a cylinder (2). The cylinder wall has an exhaust port (22) and a rear tranfer port (24) opposed thereto formed in it. The rear transfer port (24) communicates with the interior of the crankcase (14) via a rear transfer passage (37) and is arranged to open before the exhaust port (22) closes, whereby, in use, the cylinder is scavenged. An inlet duct (16) is arranged to supply combustion air to the crankcase (14) and a throttling valve (20) is arranged to throttle the flow of air through the inlet duct. A carburettor (18) is arranged to supply fuel into the inlet duct. The interior of the crankcase (14) is divided into at least two separate crankcase volumes, a rich volume (V1, V2) and a lean volume (V3). Each crankcase volume communicates with the cylinder (2) via a respective hole in the crankcase wall. The cylinder wall also has at least one lateral transfer port (26) formed in tit at a position between the rear transfert port (24) and the exhhaust port (22). The lateral transfer port (26) is arranged to open before the exhaust port (22) closes. The lateral transfer port (26) communicates with the lean volume (V3) via a lateral transfer passage (40). The rear transfer port (24) communicates with the rich volume (V1, V2). The inlet duct (16) is divided over at least part of its length into at least two inlet passages, a rich passage (42) and a lean passage (44), which communicate with the rich volume (V1, V2) and the lean volume (V3), respectively. The carburettor (18) and/or the throttle valve (20) are so constructed and arranged that, under high load operation, substantially all the fuel supplied by the carburettor (18) is introduced into the rich passage (42) and, under low load operation, the fuel supplied by the carburettor is introduced into both the rich and lean passages (42, 44).

CRANKCASE SCAVENGED TWO-STROKE ENGINES

The present invention relates to crankcase scavenged two-stroke engines and is particularly, though not exclusively, concerned with small engines of this type which are intended for use on hand-held products such as chain saws, garden blowers and the like.

The cylinder of a crankcase scavenged two-stroke engine includes an inlet port, an outlet port and a transfer port which are arranged so that the exhaust port opens before and closes after the transfer port. The transfer port is essentially one or more transfer passages which connect the cylinder and crankcase and are arranged in such a way that the piston and the cylinder controls the opening and closing of the downstream end of the transfer passages during the engine cycle. This type of engine has a hermetically sealed crankcase which communicates with the cylinder via the transfer port and with the atmosphere via an inlet duct. As the piston performs its cylinder compression stroke, air or an air/fuel mixture is drawn into the crankcase from the atmosphere through the inlet duct and on the subsequent working stroke this air or air/fuel mixture is compressed by the piston. As the piston continues to move it uncovers the downstream end of the transfer port and the air or air/fuel mixture is forced into the cylinder.

The transfer of air or air/fuel mixture into the cylinder only occurs when a positive pressure differential exists between the crankcase and cylinder. The fresh charge of air or air/fuel mixture entering the cylinder causes the displacement of residual gas from the cylinder via the exhaust port. During this cylinder scavenging process a portion of the air or air/fuel mixture that has entered the cylinder flows out of the cylinder via the exhaust port. The charge

implementation of other emissions reducing technology, the load on the catalyst must be minimised in order to reduce the size and cost of the catalyst, to minimise any increase in the exhaust gas temperature and to improve the durability of the catalyst.

The emissions performance of two-stroke engines under high load, i.e. when the throttle is wide open, is crucial for the ability of such engines to obtain certification under emissions control legislation, particularly for those engines which are intended for use with hand-held equipment. It is also under high load that the maximum catalyst/exhaust gas temperatures are reached and at which maximum thermal degradation of the catalyst occurs. Accordingly, any attempt to reduce the emissions of an engine should focus on the emissions at high load, emissions at low load being of substantially lesser importance.

Given the major significance of the emissions at high load for two-stroke engines for use with hand-held equipment, there are in practice only two types of technology that could realistically reduce the HC emissions at high load to acceptable levels, namely catalytic after-treatment and stratified charging. Catalytic after-treatment, comprising subjecting the exhaust gases to an oxidation catalyst, has been referred to above. A catalyst may also be required to reduce CO emission but it is believed that if the engine is adjusted to run with a leaner mixture it may be possible to meet the requirements of the anticipated US legislation without a catalyst. It may be possible also to meet the anticipated legislative requirements relating to HC emissions with a catalyst but the service life of the catalyst may well cause a problem unless the loading to which the catalyst is subjected can be reduced by reducing the HC content of the exhaust gas leaving the engine cylinders. It will be appreciated that reducing the HC loading on the catalyst will reduce the size and cost of the

air/fuel charge flows into the cylinder. However, scavenging is performed predominantly with the pure air which has flowed in through the other transfer passage or passages whereby the amount of unburned fuel which passes straight through the cylinder into the exhaust port during the scavenging process is reduced.

Tests have shown that an engine of the type disclosed in GB-A-2290349 has unburned HC emissions under high load conditions which are reduced by about 50%, as compared to conventional engines. However, as the engine load decreases, the reduction in unburned HC emissions decreases also until at about 40% throttle opening there is no net improvement. As the throttle is closed yet further, the unburned HC emissions are actually increased by comparison with a homogeneously charged two-stroke engine. The reason for this is believed to be that at low engine loads a proportion of the air/fuel charge flows in a direct short circuit across the top of the piston directly to the exhaust port.

A further significant problem with the engine disclosed in GB-A-2290349 relates to the fuel dispensing device which is considerably different to a conventional carburettor. Thus the deviation from known carburettor technology means that the fuel dispensing device is significantly more expensive to manufacture and it has in any event been found in practice that it is very difficult to design a fuel dispensing device which delivers the correct quantity of fuel over the entire engine operating range.

It is therefore thought that the solution to the emissions problems described above will rely upon using stratified charging at high engine load but homogeneous charging at lower engine load. It is also thought that it is

and/or the throttling valve are so constructed and arranged that, under high load operation, substantially all the fuel supplied by the carburettor is introduced into the rich passage and, under low load operation, the fuel supplied by the carburettor is introduced into both the rich and lean passages.

Accordingly, the engine in accordance with the present invention includes an inlet duct which is divided into a rich passage and a lean passage and the carburettor and/or the throttling valve are so arranged and operated that the rich passage contains a fuel/air mixture under both high and low load conditions but the lean passage contains air/fuel mixture only under low load conditions and substantially pure air under high load conditions. The rich and lean passages communicate with rich and lean volumes, respectively, in the crankcase which are separated and ideally substantially sealed from one another. The rich volume communicates with the rear transfer port, which is substantially opposed to the exhaust port, whilst the lean volume communicates with the lateral transfer port which is situated between the rear transfer port and the exhaust port.

Under high load conditions, the lateral transfer port opens before the exhaust port closes and substantially pure air flows in through it and purges the cylinder. At the same time or shortly thereafter, the rear transfer port opens and a rich air/fuel mixture flows in. However, this is retained substantially in the proximity of the cylinder wall opposed to the exhaust port by the greater and faster flowing volume of substantially pure air discharged from the lateral port whereby little or no fuel is able to flow out of the exhaust port during the scavenging process. The charge within the cylinder is thus stratified.

communicating with the two rich crankcase volumes. The inlet duct preferably constitutes a one piece casting.

The division of the interior of the crankcase into two or more substantially volumes may be effected in a number of ways. It is, however, conveniently effected by making use of the crankcase webs which are commonly provided, that is to say relatively massive discs which are integral with the crankshaft and are provided for the purpose of engine balance. Conventionally, two such crankcase webs are provided whose circular outer periphery is in close proximity to the internal surface of the crankcase. The division of the interior of the crankcase may thus be simply effected by providing a labyrinth seal or the like on the outer surface of each crankcase web. This labyrinth seal will constitute an annular groove or flange on each crankcase web which cooperates in a substantially sealed manner with a complementary annular flange or groove on the internal surface of the crankcase.

It is of course necessary for the operation of the invention that the carburettor supplies substantially all of the fuel to the or each rich inlet passage during high load operation and supplies it roughly equally to all the inlet passages during low load operation. This may be achieved in a number of ways and in one embodiment the carburettor has one or more jets arranged to introduce fuel into the inlet duct at a position immediately upstream of that at which it is divided into two or more inlet passages and the throttle valve is positioned such that, under low load conditions, it permits the fuel discharged from the jet(s) to flow into both the rich and lean passages and, under high load conditions, it directs substantially all the fuel to flow into the rich passage.

when the valve is open substantially all the fuel flows into the first passage and substantially only air flows through the second passage and when the valve is closed fuel flows into both the first and second passages. The invention also embraces such a carburettor when connected to an engine inlet duct which is divided into two separate passages, a rich passage and a lean passage, by a partition wall, the throttling valve substantially forming a continuation of the partition wall when in the closed position.

In an alternative embodiment, the throttle valve is mounted for pivotal movement about an axis which is situated upstream of the carburettor jet(s) and the throttle valve has one or more formations on it arranged to cooperate with the wall dividing the rich passage from the adjacent lean passage(s) whereby, under high load conditions, when the throttle valve is open, the carburettor jet(s) is situated in a space which does not communicate with the lean passage(s) and all the fuel flows into the rich passage and, under low load conditions, when the throttle valve is substantially closed, the carburettor jet(s) is situated in a space which communicates with the rich passage and the lean passage(s) and the fuel flows into all the inlet passages.

Further features and details of the invention will be apparent from the following description of one specific embodiment which is given by way of example with reference to the accompanying highly schematic drawings, in which:-

Fig. 1 is a side sectional view on the line B-B in Fig. 2 of a two-stroke engine in accordance with the invention;

Fig. 2 is a sectional view on the line A-A in Fig. 1;

are situated approximately midway between the exhaust and rear transfer ports. Each of these ports may be a single aperture or a number of apertures.

The crankshaft 12 is provided with two axially spaced crank webs 28, that is to say relatively massive integral discs of circular section whose outer edge is relatively close to the internal surface of the crankcase, as are commonly provided for the purpose of imparting balance to the crankshaft. The outer surface of each crank web 28 is substantially sealed to the adjacent inner surface of the crankcase by a respective labyrinth seal 30 comprising a mating annular tongue and groove. The interior of the crankcase is thus divided into three separate chambers or volumes in the axial direction, namely rich volumes V1 and V2 at the two ends and a lean volume V3 in the middle. It is not essential that these volumes be completely sealed from one another but merely that they are substantially so.

The volume between the crankcase and the underside of the piston, when in the bottom dead centre position, which is designated V4 in Fig. 1 is normally less than a quarter of that of the interior of the crankcase and normally communicates with the interior of the crankcase through a large hole. However, in the present case this hole is reduced in size by a web 32 in which there is a central hole 34 through which the volume V4 communicates only with the central lean volume V3 in the crankcase. The two rich volumes V1 and V2 communicate with the volume V4 by way of respective communication holes 36.

The rear transfer port 24 communicates with the two rich volumes V1 and V2 via a passage 37 which branches into two respective communication passages

mixture is induced into the two rich volumes V1 and V2 through the Reed valves 50. The mass flow into V3 is substantially greater than into V1 and V2. The greater volume of air entering V3 and the fact that the hole 34 is larger than the holes 36 means that V4 is filled substantially only with pure air. On the expansion or working stroke of the piston, the exhaust port 22 is uncovered first by the piston and the majority of the exhaust gas flows through it and thence away to the atmosphere. The lateral transfer ports 26 are then uncovered and pure air flows through them from volume V4 and the lean volume V3 via the transfer passages 40. The exhaust port is still open and at least a proportion of the air flows out through it, thereby scavenging the remaining exhaust gas from the cylinder. At the same time or, more preferably, shortly thereafter, the rear transfer port 24 is uncovered and fuel/air mixture flows through it from the rich volumes V1 and V2 via the passages 37 and 38. As the rear transfer port 24 is further than the lateral transfer ports 26 from the exhaust port 22 and is also inclined to direct the flow through it upwardly, that is to say towards the cylinder head, little or none of the fuel air mixture flows out through the exhaust port. This effect is reinforced by the fact that the majority of the total air input flows in through the lateral transfer ports, only about one quarter flowing in through the rear transfer port. The relatively weak flow of the air/fuel mixture through the rear transfer port is therefore "squashed" against the wall of the cylinder opposite to the exhaust port by the more vigorous flows of the lateral transfer ports and is thus prevented from flowing to the exhaust port. The charge in the cylinder is thus stratified, that is to say nonhomogeneous, with that portion of the charge which is closer to the exhaust port being weaker than that portion which is closer to the rear transfer port. Ignition then occurs in the usual manner and the cycle is repeated.

event necessary in idling operation and secondly because the fuel/air mixture is much leaner when the engine is idling than under full load because in the latter condition fuel is introduced into the cylinder only through the rear transfer port whereas in idling operation it is introduced through the rear and lateral transfer ports.

In high load operation the butterfly valve does not substantially block the inlet duct at all but it does close the aperture 68, as shown in Figure 6, and thereby ensures that all the fuel sprayed from the idle, intermediate and full load jets 60, 61 and 62 flows into the rich passage 42. Substantially pure air flows through the lean passage 44, though it is not a problem if a small amount of fuel gains access to the lean passage. The crankcase volumes V1 and V2 are thus charged with air/fuel mixture and the volume V3 is charged with substantially fuel-free air. The cylinder therefore receives a stratified charge, as described above, and scavenging losses are very low.

Under intermediate load the butterfly valve 20 occupies the position shown in Figure 5 in which both the inlet duct and the aperture 68 are partially open. Fuel is sprayed from the idle and intermediate jets and whilst most of it flows into the rich passage 42, a proportion of it also flows into the lean passage 44. The engine charge is thus what one might term partially stratified.

In a modified embodiment the inlet duct is divided by two partition walls into three inlet passages, namely two lean passages, between which is a single rich passage. The carburettor is provided with a jet arranged to supply fuel at a position which is shortly upstream of the upstream ends of the partition walls and generally between the two partition walls, that is to say in a position

CLAIMS

1. A two-stroke engine of crankcase scavenged type including a piston reciprocably mounted in a cylinder, the cylinder wall having an exhaust port and a rear transfer port opposed thereto formed in it, the rear transfer port communicating with the interior of the crankcase via a rear transfer passage, the rear transfer port being arranged to open before the exhaust port closes whereby, in use, the cylinder is scavenged, an inlet duct arranged to supply combustion air to the crankcase, a throttling valve arranged to throttle the flow of air through the inlet duct, and a carburettor arranged to supply fuel into the inlet duct, characterised in that the interior of the crankcase is divided into at least two separate crankcase volumes, a rich volume and a lean volume, that each crankcase volume communicates with the cylinder via a respective hole in the crankcase wall, that the cylinder wall also has at least one lateral transfer port formed in it at a position between the rear transfer port and the exhaust port, the lateral transfer port being arranged to open before the exhaust port closes, that the lateral transfer port communicates with the lean volume via a lateral transfer passage, that the rear transfer port communicates with the rich volume, that the inlet duct is divided over at least part of its length into at least two inlet passages, a rich passage and a lean passage, which communicates with the rich volume and the lean volume, respectively, and that the carburettor and/or the throttle valve are so constructed and arranged that, under high load operation, substantially all the fuel supplied by the carburettor is introduced into the rich passage and, under low load operation, the fuel supplied by the carburettor is introduced into both the rich and lean passages.

arranged to cooperate with the wall dividing the rich passage from the adjacent lean passage(s), whereby under high load conditions, when the throttle valve is open, the carburettor jet(s) is situated in a space which does not communicate with the lean passage(s) and all the fuel flows into the rich passage and, under low load conditions, when the throttle valve is substantially closed, the carburettor jet(s) are situated in a space which communicates with the rich passage and the lean passage(s) and the fuel flows into all the inlet passages.

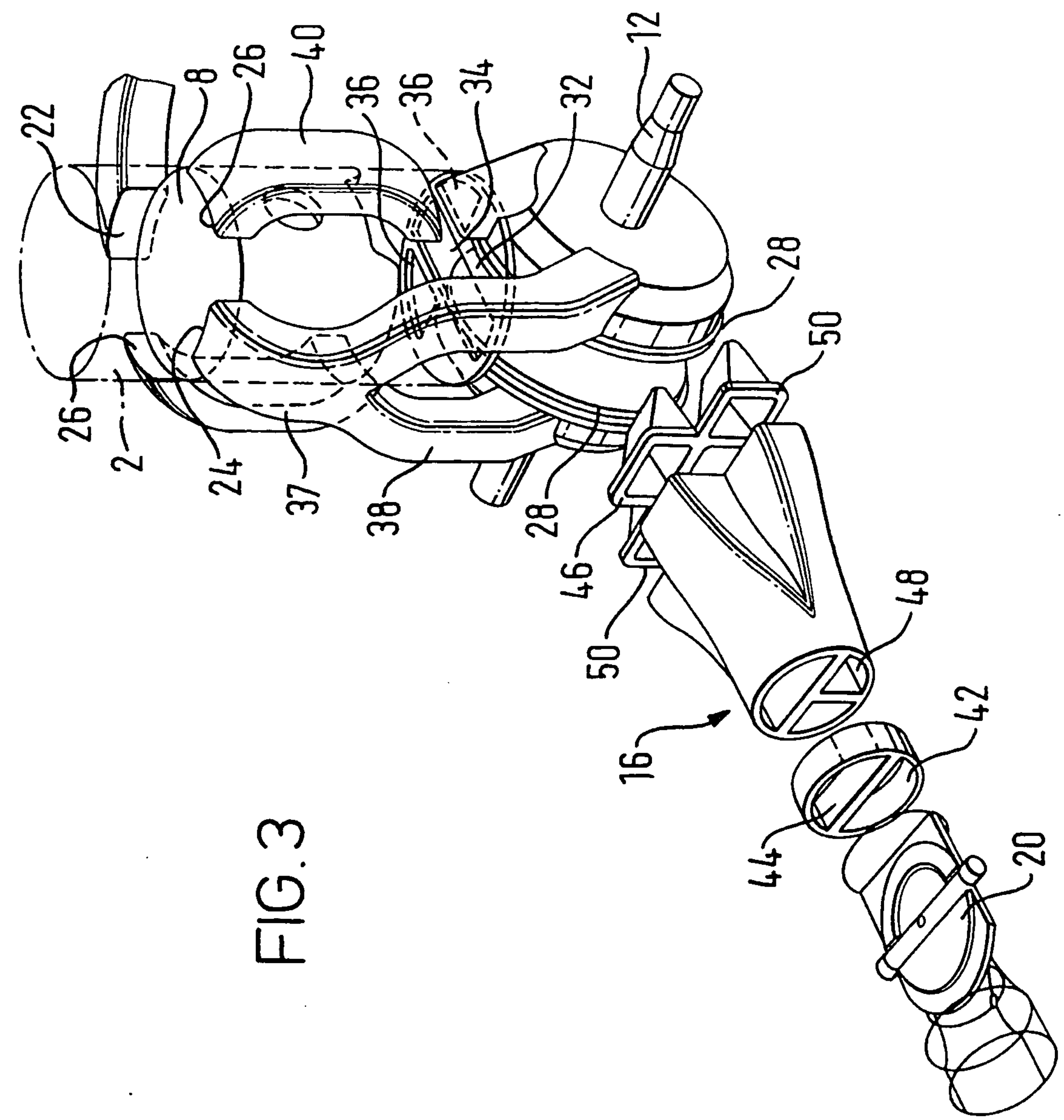


FIG. 3

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/GB 99/01412

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F02B25/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Joris, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/01412

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